

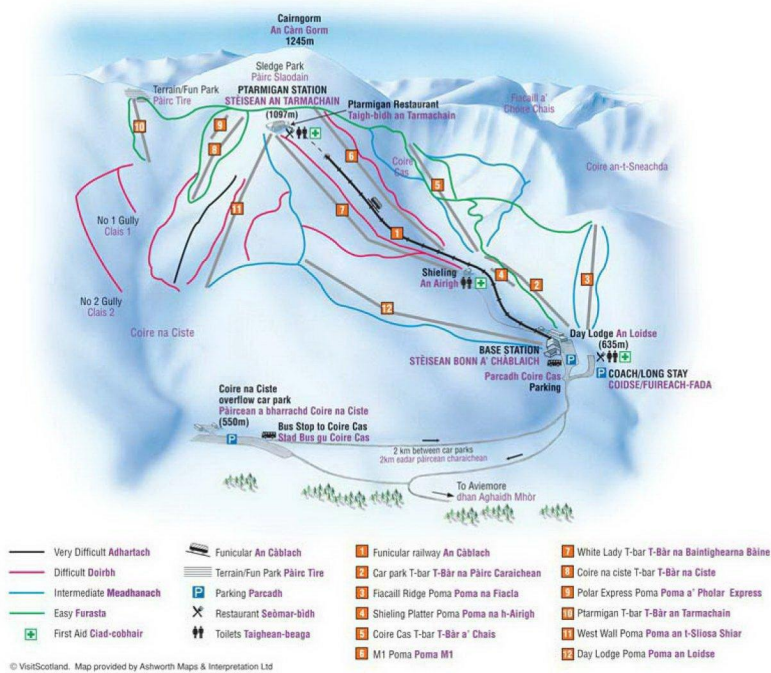
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Location map showing railway

Job name: **Condition report into concrete support structures for Funicular Railway.**
 Job number: **15015**
 Client: **Cairngorm Mountain Ltd**
 Engineer: [REDACTED]
 Date: **November 2015**

Revision	Date	Comments
A	16/11/15	Issued for tender

1. Introduction:

- 1.1 At the request of Cairngorm Mountain Ltd, the Client, the writer carried out a visual inspection of the concrete support structures to the Funicular Railway at the Cairngorm Mountain resort. The writers brief was as follows: *“To carry out a non-disruptive visual inspection of those areas that are fully exposed and to review available historic reports and construction phase drawings as made available. Plus to report on the findings along with any further action that was recommended”*. It is taken that the report is to be similar in format and detail to that produced in June 2014.
- 1.2 This report may not be relied upon by a third party for any purpose without the written consent of this practice. Furthermore, this report has been prepared and issued specifically for the benefit of the addressee and no responsibility will be extended to any third party for the whole or any part of its contents.
- 1.3 The structural inspection was carried out by means of visual inspection and measurements, generally from ground level. No disruptive investigations, geotechnical investigations or materials testing were carried out, nor were any calculations carried out.
- 1.4 The purpose of this report was to comment on the integrity of the concrete components of those parts inspected, within the limitations of the brief and inspection techniques.
- 1.5 This report specifically does not address the top or bottom station, the rails or their supports nor the running stock.
- 1.6 The inspections were carried out on a number of days through September and October. All days were dry and bright.
- 1.7 Items requiring attention in the short term are **highlighted in red**.

2. Executive summary:

- 2.1 In broad terms the writer was concerned with the general condition of the Funicular Railway given its relative young age.
- 2.2 There are numerous items of a maintenance nature that should be undertaken. A number of these should be **carried out in the short term** others can be carried out next summer season. Further, a broader range of items should be worked on to prolong the life of the structure.
- 2.3 There is particular concern around the insitu concrete linking the precast concrete beams over the piers. There is a concern that this may not be working effectively and **it is recommended that further investigations be commissioned as an immediate continuation to this report**.

3. Scope and references:

3.1 An inspection schedule was set up to look at the following areas:

- 3.1.1 Pier
- 3.1.2 Pier crosshead
- 3.1.3 Ancon bearing plates
- 3.1.4 Insitu crosshead
- 3.1.5 Insitu to beam ends:
 - Lower left
 - Lower right
 - Upper left
 - Upper right
- 3.1.6 Precast beams:
 - Lower left
 - Middle left
 - Upper left
 - Lower right
 - Middle right
 - Upper right
- 3.1.7 Rail plinths:
 - Left side
 - Right side

3.2 The referencing system is as follows:

- 3.2.1 Upper refers to the part highest up the mountain
- 3.2.2 Lower refers to the part lowest down the mountain
- 3.2.3 Left refers to the left hand side as viewed looking up the mountain
- 3.2.4 Right refers to the right hand side as viewed looking up the mountain
- 3.2.5 All references relate to the pier numbers as marked on the pier heads.

4. Funicular Railway:

- 4.1 The writer inspected the items listed in the schedule at item 3.1 of this report. It was reported that the installation had been completed in 2001, making it 14 years old. The general condition was thought to be poor for a structure of this age with wide spread minor deficiencies giving a general impression of possible poor quality control during the construction phase.
- 4.2 A pattern emerged for the deficiencies that continued throughout the length of the structure. Some items were found to be more prevalent in some areas than in others. There were also some exceptional items. This report highlights those items of immediate concern and reports in general on other observations.

4.3 Problems with grout plinths to the rails.

- 4.3.1 These plinths were in various conditions. Most were seen to be acceptable, but a number had completely failed or were in various states of decay. Others had rotting timber inclusions that clearly weaken them. Ref photos [1], [2], [3]
- 4.3.2 It is recommended that clear guidance be obtained from those responsible for the rails as to the significance of losing one of these plinths so that site operations can respond appropriately.
- 4.3.3 The observations made are replicated in Appendix A along with levels of priority for repair. A number of items are highlighted as **requiring immediate action** and were highlighted to site at the time of the observations.

4.4 Problems with the precast beams, general.

- 4.4.1 Description: Mechanical damage to the main beams, presumably from snow clearing activities. The recommendations below apply to anywhere this sort of damage occurs both now and into the future.
Location: Outside faces of beams. Specifically recorded at:

53-L/L/M
55-R/L/M
55-R/R/T
61/R/M
62
70/L
93/L/T

Recommendations: None of these items were seen to be significant in themselves, but it is recommended that where they extend to a depth exceeding 5mm that repairs are carried out to ensure the life expectancy of the structure is not compromised.

- 4.4.2 Description: Some limited reinforcement exposed in the precast beams. If these prove to be the main shear links then this reflects poor quality control at the factory. This is concerning and should be borne in mind when reviewing other parts of the structure.

Location: The side face of the precast beam webs. Specifically recorded at:

6/R/4m from top end
12/L/4m up from bottom
26/R/4m up from bottom
83/R/T in situ
93/L/M

Recommendation: Any exposed reinforcement should be fully exposed, assessed for ongoing capacity, cleaned and a patch repair carried out that will provide the bar with corrosion protection in the long term.

- 4.4.3 Description: A repeating pattern of micro cracking was observed between the bolts through the web of the precast concrete beams at the cross bracing connections.

Location: This was wide spread, but an example can be seen at beam 4 up and illustrated in photos [4], [5].

Recommendation: None of these observations were of a scale or nature to give rise to concern.

4.5 Precast beams and insitu concrete:

4.5.1 As a point of reference a couple of beams are offered as in “good” condition. From pier 49 up and pier 78 up right. All beams would be expected to be of this standard.

4.5.2 Description: Cracks were observed on the underside of most beams. Usually these were well distributed and hairline in nature and this is not of concern. In some locations the cracks were wider and extended up the face of the lower flange, these were up to 0.5mm wide. In some instances there appeared to be rust staining coming out of these cracks.

Location: Cracking to the bottom flange of the precast beams. Ref photos [6], [7], [8]

Recommendation: A detailed assessment of the magnitude of these cracks should be carried out and compared to expected crack widths. Additionally investigations into the apparent rust staining should be carried out.

4.5.3 Description: This item, in certain locations, gives the greatest cause for concern. The construction drawings made available for the insitu area are stamped “preliminary” and as such no firm conclusions can be based on them. However they show a system for mechanical coupling of the reinforcing bars to provide continuity at some locations. One of these couplers is specified as an Ancon PB32, which involves an onsite grouting operation, this would be susceptible to poor quality control. For operational reasons close quarters examination of this joint as a train passes was limited to one location, pier 56. Here the crack was clearly seen opening then closing again, by an estimated 1mm, as the train passed. The concern here is that the coupler may have failed leading to a redistribution of stress to the midspan of the beams that they were not designed to carry. Ref photos [9], [10], [11].

Location: Opening of the joint line between the precast beams and insitu fill. This was wide spread although not universal.

Recommendation: A detailed review of the as built construction and the significance of opening joints should be made along with an assessment of the load carrying capability of the beams if they are carrying additional stresses. It is recommended that this assessment be carried out as an immediate continuation from issue of this report.

4.5.4 Description: Cracking within the insitu fill, between the precast beam ends. This generally appeared as vertical cracks, often with considerable calcite bleed, sometimes white, elsewhere stained brown. Ref photos [12], [13].

Location: Insitu fill, between the precast beam ends

Recommendation: An assessment of the significance should be made as part of the review being made as part of the recommendation above.

4.5.5 Description: Fracturing of the flange ends of the precast beams, usually the bottom flange. This would suggest that the beams are not bearing evenly on the bearing plates, leading to local overstress and local failure. It is thought likely that this local failure will lead to a redistribution of stress that would re-center the load. Ref photos [14], [15], [16].

Location: Lower flanges of the precast beams where they bear on the bearing plates. Specifically recorded at:

21/R/B
25/L/T
27/L/T and R/T
32/R/B (top)
37/R/B and L/B
72/R/B (top)
76/R/B
76/L/T
80/R/T
81/L/T

91/L/T (top)
92/R/T (top)

Recommendation: As a review of this area of design is being carried out this effect should be included in that review.

- 4.5.6 **Description:** Small cracks were observed running down the top flange of the precast beams and also in some of the insitu fill areas in line with the rail fixing points.
Location: This was observed particularly in the upper part of the system.
Recommendation: This should be part of a watching brief, no action is recommended at this time.

4.6 Main piers and cross heads:

- 4.6.1 Generally these items appeared in good condition.
- 4.6.2 **Description:** Fractures of the main piers were observed in pier 91 and 92. Particularly on pier 91 these are visually significant. It is understood that these piers are formed using a precast shell with a reinforced concrete insitu fill. This being the case cracking of the external non-loadbearing shell is not thought to be a cause for concern. Ref photos [17].
Location: Piers 91 and 92.
Recommendation: A detailed review of the construction drawings should be under taken to verify this understanding and a watching brief maintained.
- 4.6.3 **Description:** Cracks, chips and missing chunks were seen in other piers. Ref photos [18].
Location: Piers 45, 54 and 57.
Recommendation: Patch repairs are recommended to match the existing. This is not thought to be urgent.
- 4.6.4 **Description:** Cracks, chips and missing chunks were seen in some cross heads.
Location: Piers 52, 55 and 87.
Recommendation: Patch repairs are recommended to match the existing. This is not thought to be urgent.
- 4.6.5 **Description:** Crack through pier cross head, running up one face and through one of the PT bolts holes on the top. Ref photos [19].
Location: Pier 93.
Recommendation: At this time this cracking is of a minor nature but should form part of the ongoing watching brief.

4.7 Specialist Ancon bearing plates:

- 4.7.1 Generally these items appeared in good condition.
- 4.7.2 **Description:** At a number of locations the insitu grout under and around these plates was seen to be deteriorating. Ref photos [20].
Location: Piers 58, 63, 76 and 86. Also inspect 89.
Recommendation: Remove deficient grout and replace. Note this is a key load bearing component and required skilled operative to carry out this work. In some cases it may require temporary propping of the main beams and closing of the railway for the duration and until the grout achieves design strength.

4.8 Miscellaneous:

- 4.8.1 The steel beams emanating from the bottom station sit onto the lowest concrete thrust block. The grout under these beam ends is crumbling. It is my recommendation that the grout should be replaced. Ref photos [21].
- 4.8.2 The rock anchors that are seen protruding from the thrust blocks and their associated bearing plates have no applied corrosion protection. Discussions with the manufacturers indicate that this is acceptable due to the type of steel used in manufacture. The bearing plates do not bear evenly and any grout under them is crumbling. It is assumed that these components are fully anchored within the mass of the concrete thrust block and that this is not an issue. Ref photos [22].

- 4.8.3 The original metal lifting eyes cast into the tops of the precast beams are exposed in many instances. These do not appear to be corroding and this is not thought to be an issue.
- 4.8.4 There is a partial walkway along the length of the railway for inspection and maintenance. It would appear that the components to complete the walkway are on site and lying on the ground. It would make inspection and maintenance work significantly safer and easier if this walkway was completed. There are a number of loose retaining clips on this walkway. These should be secured as they present a trip hazard. **It is my recommendation that this work be carried out.**
- 4.8.5 **It is recommended that** a detailed schedule for inspection in a standard format is prepared and used annually to permit comparison. The current inspection has found many more items for record than are listed here, being minor items not requiring attention at this time. It would be helpful to have these written up in the standard format.

Appendix A: Schedule of rail pack observations

Location:	Problem:	Repair priority:
Above pier number Left or right side Plinth numbered from lower end		
3/L4	Vertical crack on inner face	Watching brief
3/R4	Vertical crack on inner face	Watching brief
4/L19	Vertical crack on inner face	Watching brief
5/L20	Total disintegration	Immediate repair
6/L4	Chip out upper face	Acceptable at this stage
11/L1	Rotten wood inclusion	Remove and repair IDC
12/L8	Upper face sheared off	Acceptable at this stage
12/L15	Upper face sheared off	Repair
12/L16	Upper inner corner missing	Acceptable at this stage
12/R1	Corner fractured off	Acceptable at this stage
13/L8	There appears to be a piece of threaded bar inclusion	Watching brief
14/L6	Upper face spalling	Repair
14/L14	Upper face spalling	Repair
14/L20	Gaps	Repair
14/R4	Outer edge broken off	Repair
14/R20	Grout largely failing	Immediate repair
15/L20	Damaged	Repair
15 R/20	Damaged	Repair
16/L1	Ref pic	Repair
16/L20	Pos timber inclusion	Remove and repair
16/R7	Fractured but stable	Watching brief
17/L1	Pos timber inclusion	Remove and repair
17/L3	Pos timber inclusion	Remove and repair
17/L4	Poor repair	Break out and replace
17R/1	Damaged	Repair
18/L13	Damaged outer edge	Repair
19/L3	Pos timber inclusion	Remove and repair
20/R18	Damaged	Repair
22/L4	Spalled upper face	Repair
24/L1	Disintegrating repair	Remove and repair
24/L6	Poor repair	Replace
24/L8	Poor repair	Replace
24/R20	Outer corner damaged	Repair
26/L13	Old repair, pos damage to inside top flange.	Note
29/R1	Rail movement block upper inside corner fractured and part missing	Infill missing area.
36/L20	Possible issue	Requires closer inspection

41/L1	Missing corner	Repair
48/L4	Upper top edge missing	Note
58/L1	Pos timber inclusion	Remove and repair
58/L20	Pos timber inclusion	Remove and repair
58/R19	Grout fractured but firm	Note
61/L3	Damaged	Note
61/L20	Pos timber inclusion	Remove and repair
61/R1	Pos timber inclusion	Remove and repair
61/R12	Damaged	Repair
61/R20	Damaged	Repair
63/R20	Damaged	Repair
69/R3	Beam chipped	Repair
73/L1	Horizontal crack	Note
81/L1	Fractured upper face	Repair
91/L8	Flake off upper face	Note
93/L7	Flake off upper face	Note
93/L17	Chipped	Note
93/R20	Large chunk missing	Repair priority
<u>In the tunnel, counting from the top down:</u>		
261/L	Chipped corner	Note
268/R	Grout block split	Repair
281/L	Grout block split	Repair
284/R	Grout block split	Repair
290/L	Grout block split	Repair
291/R	Disintegrated	Repair priority
293/L	Disintegrated	Repair priority

Appendix B: **Photos:**

Ref clause 4.3.1



Photo [1] Typical grout plinth, exhibiting crazing, but stable



Photo [2] Typical case of a flake off one face of plinth. This regarded as stable.



Photo [3] Grout plinth showing fracture. Regarded as stable at this time.

Ref clause 4.4.3

Photo [4] Typical crack patterns around bolt groups.



Photo [5], ditto



Ref clause 4.5.2



Photo [6] View of crack on typical mid-span underside of beam.



Photo [7] The above photographed crack as it appears on the side of the beam.



Photo [8] Crack at mid span of beam exhibiting rust staining.

Ref clause 4.5.3

Photo [9] Pier 56, an overview showing previous repairs carried out.



Photo [10] Pier 56 crack near top of flange unloaded.



Photo [11] Pier 56 crack near top of flange as train passes. Estimate increase in crack width = 1.0mm.



Ref clause 4.5.4



Photo [12] Pier 8, one of the poorer insitu infills. Showing joints opening between Insitu and precast plus cracking within the mass of the Insitu, both inclined and near vertical.



Photo [13] Pier 8 from above.

Ref clause 4.5.5



Photo [14] Diagonal cracks through the lower flange of the precast beam bearings.



Photo [15] Showing bottom corner fracturing away.



Photo [16] Flange fracture also seen at top of beams. This was less often.

Ref clause 4.6.2



Photo [17] Main pier 91 showing cracks in shell.

Ref clause 4.6.3



Photo [18] Significant chip out of pier shell.

Ref clause 4.6.5



Photo [19] Pier 93. Crack rising up through pier crosshead and passing through bolt group. This was the only cross head where this was observed.

Ref clause 4.7.2



Photo [20] Showing deterioration of bearing plate grout.

Ref clause 4.8.1



Photo [21] Crumbling grout pack under steel beam at pier 0.

Ref clause 4.8.2



Photo [22] Typical thrust block rock anchor head.